canusa
Canada
United States
Spruce Budworms
Program

Newsletter

NUMBER 20, JANUARY 1982

Budworm in Oregon, 1981

Forest Service Region 6 reports that there was little evidence of western spruce budworm in Oregon in 1979 - one had to look carefully to find a trace of feeding in any of its normal habitats. But in 1980, an aerial survey revealed approximately 8094 ha (20,000 acres) of light defoliation in the northeastern part of the State. Following the aerial survey, both pheromone traps and egg-mass surveys showed little evidence of budworm outside the defoliated areas. In 1981, 108 456 ha (268,000 acres) of defoliation in varying intensity have been mapped. The Umatilla is the National Forest hardest hit, followed by the Wallowa-Whitman and the Malheur Forests.

A cooperative effort between research and Regions 1, 4 and 6 is producing an intensive study of egg-mass distribution under a variety of site and stand conditions and at differing budworm densities. This work should result in a better understanding of adult budworm movement and egg-mass deposition, and lead to improved survey techniques. New pheromone trap designs are being tested in other areas of eastern Oregon and Washington in an attempt to find a means of detecting potential heavy defoliation a year in advance.

Jim Colbert - Research Coordinator, CANUSA-West
Portland, Oregon

Spruce Budworm Modelling Workshop

On October 6 to 8, 1981, 27 modellers met at the headquarters of the North Central Forest Experiment Station in St. Paul, Minnesota, to discuss the current status of spruce budworm modelling efforts in North America. This first meeting was planned as a time for individuals to become acquainted and discuss their research. The discussions were restricted to basic concepts and modelling theory. Future meetings will involve the user community and implementation planning. Chuck Buckner and Bob Talerico jointly chaired the workshop, and Bob Talerico compiled this report from summaries submitted by discussion leaders.

General Session

Tuesday was devoted to individual presentations. Those of the western Program were presented first. Jim Colbert described the process of soliciting user participation in model formulation, and model development history. Nick Crookston described the PROGNOSIS model for stand development and yield, indicating its preprogram inception in the late 1960s, its evolution and current capabilities, and associated options. Tom Bible described how models CANUSA is developing will be used to display economics associated with options in land-use planning and forest management. Next Bill Kemp described the logic of the western spruce budworm model components and how they are integrated into a stand simulation. Bob Campbell then reported on the research studies supporting the budworm model and emphasized the most significant results to date. Dale Everson explained the weather analyses to be performed. Alan Thomson recounted some history of models developed for western budworm dynamics in British Columbia before CANUSA's inception and explained the influence of past and present western Canadian entomological research on CANUSA-West modelling efforts. Finally, René Alfaro described impact studies being done at the Pacific Forest Research Centre and the resulting model components for describing tree growth effects, top kill, and mortality as functions of defoliation history.

Representing CANUSA-East, John Hudak reported on the history of budworm outbreaks in Newfoundland and current studies that might interest modellers. Mike Ker reported on tree biomass equations plus growth and yield response of balsam fir to thinning regimes. David MacLean described historical records of defoliation and management practices (particularly thinning) and plans for analyses of whole-tree samples in the same plots. Bob Fisher described a model developed to allow policy makers to simulate the effects of various control options on budworm populations and forest volume in New Brunswick. Tom Royama described a synoptic model of budworm dynamics and comparisons of that model with Green River data and the Holling model. Jacques Regniere described a variation of Royama's single equilibrium model and its possible biological implications. Christine Shoemaker reviewed a model of balsam fir phenology and its relationship to budworm control, and described means for statistical estimation of budworm phenology from field data. Rich Fleming described calculations of year-to-year transition probabilities for budworm. Jan Nyrop reported on effects of stand structure and species composition on parasitism rates. Bill Mattson reported on relations between host plant and budworm traits and how host traits allow population release. Gordon Mott described studies on vulnerability of mixed balsam fir stands and the effects of fir removal upon budworm attack in those stands under various suppression treatments. Dale Solomon and Pete Hayslett described models of foliage dynamics and effects of defoliation on foliage dynamics and subsequent stem volume loss.

Population Dynamics

Chairman: Bill Mattson

Jan Nyrop, Tom Royama, Jacques Regniere, Gary Whitfield, Bob Campbell, Nilima Srivastava, Bill Kemp, Kathy Sheehan-Akers, Rich Fleming, Dale Everson, Chuck Buckner

This workshop began with a review of both existing and proposed models. Previous modelling efforts in the East had centered on the Holling model and/or its variations (e.g., J. Stedinger's model). However, these models are not widely used at present. Perceived shortcomings include both the double equilibrium levels and the assumption of stand age and small larval survival as driving forces for this system. A proposed single equilibrium model by Royama duplicates the observed occasional population buildups and is not driven by stand age and small larval survival. Using another, process-oriented approach, Gage and Sawyer have developed a model in which predation plays an important role. The data base for the eastern models consists largely of the data gathered by Morris and others in the 1950s at Green River.

In the West, process-oriented models have been developed by Thomson (a model specific to British Columbia) and McNamee and others (a model intended to identify directions in which further research was needed). A second version of the McNamee et al. model linked this western budworm population dynamics model with the PROGNOSIS model developed by Stage and others. A third revision, currently underway, is based on recently acquired or expected information about western budworm biology and ecology. The western Program's goal is to accurately describe budworm responses to and effects on forest stand dynamics (as reflected by the PROGNOSIS model).

Some inherent problems in population dynamics modelling were reviewed, including the following topics:

The danger in misapplication or over-reliance on these models either for determining research directions or making management decisions.

The long-standing quandary regarding the partition of research resources: should studies be focused on a few areas for a long time, or on more areas for a shorter time?

Further, even the relatively extensive Green River data base represents, in effect, only a snapshot of the total length of the crop-tree's rotation.

Contrasts between eastern and western population dynamics were also discussed, with particular attention to implications for modelling efforts. Some of the important differences noted include relative importance of certain natural enemies, adult dispersal (mass flight, influence of topography and weather), and hibernaculum locations. The relationship between E/M (ratio of observed to expected eggs) and expected eggs was similar for both eastern and western budworms. The large variability in the above relationship for western budworm is an example of interactions that may be recognized.

Forest Dynamics Subgroup

Chairman: Dale Solomon

Dave MacLean, Mike Ker, René Alfaro, Nick Crookston, Bob Talerico, John Hudak, Pete Hayslett

Workshop participants reviewed the different forest growth models currently available and discussed differences between eastern and western approaches to defoliation and growth loss.

Participants felt that in the East, more data are needed on the defoliation and growth response (height growth by species) of stands less than 30 years old. Data on tree growth response need to be expanded to include spruce and mixed-wood situations.

Discussions revealed a need for an overall tree and stand growth model for Eastern Canada and the Eastern United States. The group felt that such model development should be supported by CANUSA. The general feeling was that an individual tree-distance independent model would be best, but other types should also be developed (e.g., stand models, individual tree foliage models, etc.) to meet specific user needs. These models should aid communication between researchers and serve as a framework for integration and coordination of studies, as well as produce "interpretable output." These models should include growth-defoliation concepts and be capable of producing wood supply predictors based on available inventory data.

The western PROGNOSIS model needs to be made adaptable and compatible with the British Columbia inventory system. This adaptability should be a common trait of all forest management-oriented growth models so that they can be applied to different regions.

Economic/Social Policy

Chairman: Jim Colbert

Bob Fisher, Al Thomson, Christine Shoemaker, Tom Bible, Gordon Mott, Chhun-Huor Ung (Nick Crookston and Pete Hayslett joining later)

This group discussed models currently being used in Maine and Eastern Canada and how important documentation of models is to CANUSA researchers. Even though models are evolving and research may substantially alter them in the near future, they must be available now if they are to affect the CANUSA Program's modelling effort.

The dissimilar land ownership patterns between the United States and Canada and between the East and West make the basis for policy and management decisions quite distinct. The models must be capable of dealing with these decision bases. In all cases the major decision criterion appears to be ultimate impact on the work force or jobs.

Discussion next focused on the proper measures of budworm damage. Defect is a most important measure of budworm effect on sawtimber, and volume changes are the most important on pulpwood.

To properly address management and planning issues, models must be sensitive to interactions of spruce budworms and management activities. For example, models

must incorporate not only how management activities affect the budworm, but also how the budworm affects stands managed through chemical, bacterial, or silvicultural prescriptions.

Another key point and apparent problem is that management does not account for the indirect effects of a particular prescription on the future of other stands in the same management unit. A management action today may affect the planned land allocation and harvest schedule for any stand considered in the rotation period. The effect of the budworm on harvest schedules is a manager's greatest concern today.

It was pointed out that in the West there is no recognition of economic ramifications of old or uneconomic facilities. Models should be sensitive to these problems.

Although the effects of the budworm on forests have been investigated, the opposite—the effects of forest management practices on budworm dynamics—has not received sufficient attention. Program management should support more work in this area.

Separate models for insect, forest, and management policy questions are inappropriate for CANUSA's charter. We need models that will yield answers to questions of entomology, silviculture, yield, planning, and scheduling if we are to have truly integrated management of the forest for maximum public utility.

Basic inventory costs and procedures will most probably need changing because the budworm will cause increased variation in parameters being measured. Management inventories must be done on a stand basis.

Synthesis

Chairman: R. Fisher

The discussions of the concurrent sessions were reported to the group. After additional deliberations, attendees made the following recommendations to Program Management:

1. The western modelling effort has provided a focus for all component researchers. A similar effort might be effective in the East.
2. The western component has benefited from the existing, accepted, and widely used PROGNOSIS model. Because there is not a similar model in the East, the eastern component should develop a mixed-wood forest stand model with a foliage component.
3. The economic effects of budworm activity should be explicit and include the consequences of public subsidy. The effects of current management options on future value and changes in harvest schedules should be recognized.
4. Models should contain an option to provide for the effects of management action on spruce budworm population dynamics.

Future Plans

1. A small group of eastern modellers will meet in Sault Ste. Marie, Ontario during this winter to develop a conceptual framework for an eastern spruce budworm model. The primary output will be a flow diagram of system components for this model.
2. Another meeting of the whole Modelling Group might be convened in the spring to evaluate the aforementioned framework and suggest revisions and refinements.
3. Similar East-West international workshops in the following areas were suggested:
   A. Impact of budworm defoliation on tree growth and yield.
   B. Population dynamics of large larvae (L4-pupae), including mortality factors and natural enemy dynamics, and feeding/foliage dynamics.
   C. Analytical methods for historical data analyses.
4. Compilation and documentation of available records pertinent to CANUSA research and related information. As a start, abstracts for research projects sponsored by CANUSA-West are available from Program Management in Portland, Oregon.

Working Group Meetings—CANUSA-West

Opening Remarks

The 1981 CANUSA-West working group meetings were held in Portland, Oregon, on October 26-29. Program Manager Ron Stark opened the meeting by welcoming everyone and briefly describing the effects that proposed budget cuts may have on CANUSA projects. Nilima Srivastava and Nick Crookston reported highlights of the CANUSA-East working group meetings, which they had attended the previous week. The remainder of the first day was spent presenting the combined stand PROGNOSIS/western spruce budworm model. These discussions were intended to provide investigators with a framework for presenting their results, especially applications for use by forest managers, pest managers, and planners.

Jim Colbert reviewed the previous versions of the budworm population dynamics model and introduced the current modelling team. Nick Crookston reviewed the stand PROGNOSIS model, emphasizing recent changes and additions, such as the capacity to process several stands simultaneously.

Kathy Sheehan-Akers (insect modeller, filling the vacancy left by Peter McNamee) then described the two main budworm dynamics components—one that follows adults through dispersal and oviposition, and another that follows the budworm from eggs to adults (using cohorts of both budworms and foliage, and time-dependent feeding and mortality rates). Nick Crookston presented a review of the budworm damage component, showing how PROGNOSIS translates defoliation into growth loss, top-kill, and mortality.

Tom Bible concluded the first day's meeting by describing what information a forest manager or planner needs to evaluate the impacts of budworm activity on plans and management actions. He described how budworm impacts may affect a forest plan indirectly through changing sustained yield and the latter's effect on allowable cut and rotation age.

Jim Colbert, CANUSA-West's Research Coordinator leads the discussion on opening day.

Wellington on Weather

Dr. William G. Wellington, Joint Professor in Plant Sciences and Institute of Animal Resource Ecology at the University of British Columbia, and recent recipient of the 1980 Woodard Award in Ecology, presented the principal keynote address. Dr. Wellington began by speaking about the influences of local terrain on weather and reminding us that we are "bottom dwellers" in an ocean of air. Using a spectacular slide presentation, he emphasized that we need to be aware of the total air patterns and currents as well as the effects of local terrain.

Weather and local topography may affect budworm dispersal in several ways. Dr. Wellington described how storm systems usually move quickly across plains, but tend to slow down at major ridges (especially warm fronts). Cold fronts are generally superior to warm fronts for short-range dispersal (due to the quick "scouring" action as one moves into a valley), but not for long-range dispersal since these cold fronts tend to deposit material after travelling a relatively short distance.

Certain mountain peaks are typically "cloud generators," for the early morning sun striking the east faces of these peaks creates rising masses of warm air that condense near the peaks. Often lines of clouds are visible extending out from these cloud-generating peaks. The rising warm air is usually replaced by cooler air from across the valley; the resulting cross-valley wind currents have been shown to be important carriers of balsam woolly aphid crawlers, and may also influence budworm dispersal.

Persistent cloudiness may also disrupt dispersal of adults, which probably use polarized light as a guide to movement. Water droplets in the clouds disrupt the polarized pattern. Although the response of budworms to polarized light has not been established, the moths do normally fly during times of maximum polarization (i.e., dawn and dusk).

Budworm mortality can also be affected by interactions of weather and local terrain. A winter with many warm fronts (and the attendant alternate thaws and freezes) may result in high insect mortality at certain elevations. Conversely, Dr. Wellington noted that during a winter with relatively few warm fronts, increased insect mortality may occur at valley bottoms due to the settling of cold air in drainages. The cloud lines generated by certain peaks may also affect budworm development and mortality rates because of changes in temperature, precipitation, and relative humidity in the cloud shadows.

Finally, Dr. Wellington described how certain valleys tend to "punch holes" through fronts (or at least create thinner patches), so that these valleys, if they contain host species, may provide slightly more favorable conditions for budworms during otherwise harsh times, and thus serve as budworm refuges. Information from the LANDSAT program, which in the past has concentrated on cloud-free areas, should be used to identify cloud generators and cloud-free valleys within otherwise cloudy areas. The interactions of weather and local terrain in these areas may be critical to budworm population dynamics.

Following Dr. Wellington's presentation, Ron Stephens of the National Weather Service (NWS) described meteorological models used by NWS and the history of synoptic weather models developed over the past three decades. He gave examples of the rapid development in models, which are growing as fast as computer technology has allowed. The most recent NWS models have improved considerably in accuracy but still can predict only 72 to 96 hours into the future before internal errors in computation and formulation significantly reduce their reliability. Many users of weather data want 1-year predictions, but Ron feels that these will not be available with any degree of accuracy or reliability in the foreseeable future.

Investigator Presentations

Stand Initiation—The initiation of an outbreak simulation starts by identifying the questions a simulation might answer. Al Stage led off the investigator presentations by describing how the resolution of a question determines the accuracy and precision of information needed to answer the question. He pointed out that accuracy is not always important, particularly if answers are obtained through comparisons of a number of alternative outcomes. His discussions also noted that models, though developed in detail, may eventually be abstracted for efficient use in specific situations.

Bruce Kessler described the photo interpretive hazard-rating system developed by Bob Heller and Hal Anderson. These models were developed by exploring high-resolution aerial photos (1:2,000 scale) for site and stand conditions associated with budworm defoliation.

Peter Mika described a more intensive on-the-ground study made under the direction of Karl Stoszek to determine site and stand conditions that are associated with intensity of defoliation by budworms. Stoszek's study served also to groundcheck the broader scale of Heller's

work. These two studies will produce the probability of involvement to "turn on" the budworm model within PROGNOSIS simulations of susceptible stands.

Tom Hinckley discussed his work developing the relations that will allow dynamic allocation of foliage biomass to model trees. Based on the principle that sapwood is the conduit to support foliage and the tree's woody growth, his work will allow us to predict more accurately the amount and distribution of new foliage biomass—the food for western budworm.

Bill Kemp described the study of Dale Everson and Don Burnell that will investigate synoptic weather and associated budworm activity. Historical budworm and weather data will be used in this work to investigate approximately 50 variables. Where detailed climatological data can be obtained, more detailed models of effects of microclimate on the budworm will be investigated.

Bill Waters described the foliage measurements being made in association with the life tables he and Jan Volney are producing. They have detailed measurements of foliage surface area and shoot counts by species and crown strata and are also capable of describing the foliage distribution in a stand canopy. Bill questioned the need to keep track of foliage biomass.

Colin Henderson presented host foliage defensive chemistry research being done under the direction of Rex Cates. After identifying a set of biochemical quantities associated with lower defoliation and decreased weight of adult budworms, he discussed laboratory feeding studies designed to determine which associations cause changes in budworm growth and mortality rates. Colin also described research which has shown that increases in moisture stress result in decreases in the host's ability to produce defensive chemicals.

Budworm Ecology—Discussion of studies related to western budworm population dynamics started with several presentations of general applicability, and then focused on specific processes in the budworm's life cycle. Gary Long began by describing a series of "outbreak maps" he has constructed for 1955 to the 1970s. In some cases the change in outbreak acreage can be described by a simple model, which assumes dispersal occurs in random directions from a center.

John DeBenedictis, representing Jerry Powell, discussed the taxonomy of western *Choristoneura* species and subspecies, noting their hosts, geographical ranges, pheromone specificity, and intrapopulation genetic variation.

Bob Stevens described two identification keys that he and Val Carolin published—one for associates of small budworm larvae (in buds and needles), and one for associates of large budworm larvae (on foliage). He also expressed his willingness to assist investigators in identifying specimens, especially if the appropriate host/collection information is provided.

Adult dispersal was the first specific process to be discussed. Dick Silversides reported the results of a wind model, which predicts the influence of terrain on local winds (generally for a 25- to 100-km^2 area). This wind model could be used to predict areas of wind convergence, or divergence, as a step toward predicting adult dispersal patterns.

Roy Beckwith (left) makes a point with Jim Colbert and Garrell Long during a break in the action.

Maurice Danard then described in detail a one-level mesoscale wind model. Further refinement of the temperature-related components is required because budworm adults fly during times of maximum temperature flux. These are the most difficult times for the wind model to simulate.

Nello Angerilli, representing John McLean, reported that they can label budworms by injecting rubidium chloride into host trees; x-ray energy spectrometry (XES) can then be used to detect the label, and thus trace budworm dispersal from the labeled tree.

Bob Campbell described the great variation that he and Torgy Torgersen have found in the ratio of observed to expected eggs. They noted that this ratio decreases steadily as the number of expected eggs increases, and that similar results have been found for eastern budworm studies.

Mike Wissenbach began the discussion of oviposition by describing his studies of budworm activity on juvenile western larch; during two field seasons, no budworm eggs were found on these small larches. Bill Waters reported that he and Jan Volney have egg deposition data available, by both individual tree crown and stand-wide canopy strata, for several stands. Torgy Torgersen discussed some between-crown-level egg distribution data that he and Bob Campbell have collected (analysis of this data is continuing).

An automatic egg-mass counter, whose development is being sponsored jointly by CANUSA-East, -West, and USDA Forest Service Forest Pest Management was briefly described by Jim Colbert.

Egg viability and mortality was addressed by Bill Waters, who presented information that he and Jan Volney have collected showing proportions of eggs that: don't develop, develop but don't hatch, hatch but don't hibernate, or successfully hibernate. The range of mortality from eggs to hibernating larvae showed great variation.

Work by Tom Egan on overwintering mortality was briefly reported by Roy Beckwith. Hibernacula were tagged and checked periodically for larval mortality. Tom has also done some work with exclusions of various sizes. Val Carolin described previous observations of clerid and snakefly predation on larvae in hibernacula, and the characteristic feeding patterns of those predators.

Spring dispersal was first addressed by Jan Volney, who discussed laboratory work that he and Bill Waters have done on the temperature thresholds for emergence of several populations. He noted differences within and between populations.

Don Burnell then described work that he and Roy Beckwith have done involving the placement of sticky traps at three heights in small forest openings. They found very few first-instar budworm larvae, approximately 60 percent second instars, and roughly 40 percent third and fourth instars in these traps, and noted that total trap catch was greater in the higher traps.

Developmental rates were then discussed. Bill Waters described his and Jan Volney's population sampling methods, which yield information on cohort structure, host phenology, feeding rates, and amounts of foliage consumed. Climatological information is available from nearby weather stations. Jan also mentioned that they have studied development rates of budworms raised on diet in the laboratory.

Budworm feeding rates and host foliage destruction for several host species were described by Mike Wagner. Preliminary results indicate that Engelmann spruce may be a more suitable host than is generally believed.

Natural enemy population dynamics and associated budworm mortality rates were addressed next. Bob Campbell and Nilima Srivastava discussed the effects of excluding birds and/or ants. They noted that birds and ants compensate for each other, so that budworm survival increases noticeably only when both are excluded.

Oz Garton and John Takekawa described their work on functional and numerical responses of insectivorous birds, particularly evening grosbeaks. They observed foraging behavior (in field and lab), analyzed stomach contents, and conducted caged feeding trials. A calculation of economic value of evening grosbeak predation on budworms was presented.

Lorna Youngs discussed her work with predaceous ants, noting the difficulty of both estimating population density of certain species and determining the species composition of the foliage-foraging ant community.

Milt Stelzer described his studies with two budworm viruses (one NPV and one GV) at two timings and three dosages. Fairly good foliage protection resulted, with no responses to different timings or dosages and little carry-over to the following year. Roy Shepherd noted that John Cunningham's work shows similar results, except that he did find some carryover of the virus, and that he had also found a change in the sex ratio (reducing the number of females by roughly 50 percent). Roy also described the recent successful application of virus to an increasing Douglas-fir tussock moth population in British Columbia, noting especially the rapid spread of the virus from points of application.

Pupal mortality was first discussed by Jan Volney. He and Bill Waters have partitioned pupal mortality (parasitized, preyed on by insects, or missing) according to microhabitat, host species, and crown level. Bob Campbell then described observations that he and Torgy Torgersen made of budworm mortality from fifth instars to adults. They found variation in mortality rates in different crown levels. Bill Waters finished the discussion of mortality with a presentation of mortality curves based on Jan Volney's and his whole-branch sampling method. They noted differences between both crown levels and canopy levels.

Effects of Defoliation—On Thursday morning the reports turned from budworm ecology to effects of defoliation on hosts. Some of these effects had been discussed earlier when foliage distribution and tree growth were

Bob Campbell joins a table of investigators discussing bird predation on western spruce budworm.

covered. Don Burnell described residual foliage biomass as a predictor of tree growth. Dennis Ferguson and Clint Carlson described how their research will extend the PROGNOSIS model's ability to simulate the establishment and growth of young trees. Clint also described how his research will allow assessment of various harvest methods and site preparations for regeneration prescriptions.

Ray Shearer described how the budworm affects cone crops through destruction of reproductive buds, developing flowers, cones, and seeds. Bruce Kessler described a photo guide for assessing defoliation on the major western hosts. This guide, started by Hal Anderson, will provide stereo-photo pairs of trees showing various amounts of defoliation and the associated mid-crown branch photos. It will be used to train field crews to rate defoliation.

Roy Shepherd described work initiated by Alan Van Sickle and being continued by René Alfaro and Alan Thomson. They are assessing radial growth loss up the stem, height growth loss, and top-kill, as well as mortality of Douglas-fir caused by budworm defoliation. Roy showed the distribution of mortality by dominance class and models for the effects of accumulated defoliation on tree growth.

Cathy Stein described the work being done on loss assessment in Forest Service Region 3 and how difficult it is to determine top-kill from the ground during an infestation. She also described the environmental impact statement (EIS) for the Carson National Forest that will advise spraying a portion of the current budworm outbreak area using carbaryl, except in sensitive areas where B.t. is advised. She said an EIS for budworm management options on the Sante Fe National Forest is in preparation. Bob Harvey also described similar loss assessment surveys being done in Region 6.

Secondary infestations in defoliation-stressed trees were noted. Donn Cahill discussed the various foliage measurements being used by investigators and described a grid method that he feels will improve the accuracy of such measurements. Dennis Ferguson described the impacts of budworm feeding on small trees' height growth and how terminal bud destruction will cause tree deformities that will eventually affect log quality.

A short discussion followed on the modelling of recovery of a tree from defoliation. Apparently, while investigations are underway studying the effects of defoliation on growth, there is not sufficient time to study the recovery of trees where defoliation histories are being accumulated.

Application Study Results

Thursday afternoon was spent discussing uses of research and development work being done by Program investigators. Hazard rating was discussed first. The question of scale of photos necessary to rate hazard was raised (1:24,000 are regularly available, although models have been developed using 1:2,000 scale). Management representatives were concerned that some variables that

predict hazard are not available from standard inventories or photos. Dan Twardus pointed out that the hazard models presented were describing degree of defoliation rather than probability of involvement or probability of initiation of an outbreak in a stand. Forest pest managers requested a means to identify potentially or chronically infested areas rather than specific stands first.

Roy Shepherd felt that risk rating may never be satisfactory because of the large role that weather has in driving population trends. Discussion then turned to the need for reliable forecasts of a population trend for one year in order to plan for direct suppression operations. Nilima Srivastava described the problems with accuracy of egg-mass samples and studies underway to increase reliability of these samples. Larry Stipe described the silvicultural demonstration areas in Forest Service Region 1 and stressed that forest managers are interested in management through silvicultural prescriptions and want to incorporate this into their long-term plans. The planning function is becoming the most important job on national forests.

Bruce Hostetler described the problems that the USDA Forest Service and Oregon State Forestry Service are having in getting sufficient data to make analyses. This dearth of information has forced the interdisciplinary team that is preparing the environmental assessment of the recent outbreak in eastern Oregon to do a more simplistic economic analysis than they would prefer.

Tom Bible supported their plight by describing the type of yield data that are required to make accurate predictions of losses. Tom also pointed out that accuracy of predicted losses may be as important as prevention to long-term management of forests. Planners need to know what impacts budworm might have on a national forest plan; substantial volume changes can make a plan infeasible, but this may not be recognized for decades if impacts cannot be reasonably predicted.

The subject of threshold *v.* planning models was the final topic discussed. The Program is working on both of these types of models. It was pointed out again that short-term predictions, of necessity, depend upon a more complex base to provide required accuracy. These models are of interest to forest pest managers for short-term population predictions.

Jim Colbert — Research Coordinator, CANUSA-West
Portland, Oregon

Eastern Spruce Budworm Council Meets in St. John's, Newfoundland

The Council held its fall meeting in the Newfoundland Hotel, St. John's, Newfoundland, on November 9-10, 1981. The Chairman, Don Eldridge, Deputy Minister of Lands and Forests, Nova Scotia, and member of the CANUSA Joint Policy and Program Council, steered a lively meeting through an interesting and provocative agenda. Reports on the status of the current infestations from the various jurisdictions represented at the table indicated changes in both upward and downward population directions, with no clear indication of an overall abatement.

Program leaders from both the United States and Canadian CANUSA components were present to answer queries about the Program. Focus was provided on the progress of transition planning, which is of sharp interest to those managers experiencing serious budworm problems. A review was also presented on the status of the more prominent portions of the Program.

H.J. "Bud" Irving and Charlie Weisner (Forest Protection Ltd. and N.B. Research and Productivity Council, respectively) presented plans for a new cooperative application technology thrust, Spray Efficacy Research Group (SERG—pronounced "serge"), to coordinate research aimed at improving performance and reducing off-target impact. A number of CANUSA studies and projects relate.

CANUSA Goes to San Diego

The program for the 1981 Entomological Society of America national meeting (Nov. 29-Dec. 3) included at least 10 scientific papers on spruce budworm. A broad array of topics was represented: chemical insecticides (Jackie Robertson), B.t. (Dick Reardon), budworm genetics (A.M. Liebhold, Jan Volney), fungi (K.P. Lim), physiology (Art Retnakaran), and pheromones (S.B. Ramaswamy, A.R. Alford, Charlie Wiesner). Ask the authors for details.

We remind you that the joint meeting of the Entomological Society of Canada and Entomological Society of America in December 1982 presents an especially appropriate opportunity for conferences and symposia on the spruce budworm. Please keep your CANUSA Program Leaders informed of your efforts to organize such events.

Management Guides for Western Spruce Budworm

Detailed planning of the three books on western spruce budworm for forest managers took place at an author's conference November 17-19, 1981. Beginning with outlines provided by the Technology Transfer Working Group, the writers refined and amplified the table of contents, which includes the biology of the host and insect, their interactions, management operations, and regional planning.

Objectives of the meeting included identifying the audience, establishing language level and style, defining lead authors' opinions and responsibilities, setting up review procedures and schedules, and establishing a system for cross-referencing.

The following participants accepted writing assignments for parts of the books: Tom Bible and Richard Hermann, Oregon State University; Ralph Johnson, Larry Stipe, and Bill Wulf (Region 1), Dan Twardus (Region 6), Bob Campbell (Pacific Northwest Station), Al Stage (Intermountain Station), and Val Carolin (retired), USDA Forest Service; Shelley McIntyre, senior

in environmental law, Lewis and Clark College; Bob Heller, University of Idaho (retired); and Alan Van Sickle, Canadian Forestry Service.

Martha Brookes, editor at the Forestry Sciences Laboratory, Corvallis, will assist with planning and coordinating the writing of the books. In addition to her experience editing the multiauthor compendium produced by the Douglas-fir tussock moth program, she has worked with the CANUSA-West Working Group in developing its total technology transfer plan.

Spruce Budworms Infestations in the United States in 1981

The Forest Pest Management division of the USDA Forest Service provides annual estimates of visible defoliation by the spruce budworm and western spruce budworm in the summer months. The following table compares acres defoliated in 1980 with the preliminary estimates for acres defoliated in 1981.

Defoliation in 1981 appears to have been somewhat less extensive than in 1980. There were slight increases in the West. The most significant changes were reduced defoliation in Maine and Vermont in the Northeast and Michigan and Wisconsin in the Lake States.

Projections for 1982 based on 1981 egg-mass surveys will be reported in a later issue of the *Newsletter*.

	1980		1981	
Area	Acres	Hectares	Acres	Hectares
Western Forest Service Regions				
Northern	976,072	395 003	932,403	377 331
Rocky Mountain	1,052,000	425 730	1,200,000	485 623
Southwestern	299,000	121 001	330,000	133 546
Intermountain	1,522,000	615 932	1,523,000	616 337
Pacific Northwest	229,400	92 835	306,380	123 988
Subtotal	4,078,472	1 650 501	4,291,783	1 736 825
Northeast				
Maine	5,000,000	2 023 430	3,500,000	1 416 400
New Hampshire	90,000	36 422	100,000	40 469
Vermont	110,715	44 805	40,000	16 188
Subtotal	5,200,715	2 104 657	3,640,000	1 473 057
Lake States				
Michigan	859,500	347 828	160,940	65 130
Minnesota	103,000	41 683	109,692	44 391
Wisconsin	439,000	177 657	84,486	34 190
Subtotal	1,401,500	567 168	355,118	143 711
Total — United States	10,680,687	4 322 326	8,286,901	3 353 593

Cash Flash

Dan Kucera keeps track of requests for Federal financial aid in suppressing forest insect pests in the 20 States that make up the Northeastern Area of State and Private Forestry. For 1982, only two States have asked for budworm-suppression money—Maine ($2,664,000) and New Hampshire ($300,000). The New Hampshire request is a first, Dan reports.

Altogether, 11 States have asked for $14.4 million in Federal funds to help fight gypsy moth, spruce budworm, forest tent caterpillar, saddled prominent, and bagworm. This total represents less than half what the States expect to spend on suppression activities in 1982.

New Lab to Study Reye's Syndrome

The Ohio State College of Medicine and the National Reye's Syndrome Foundation announced the opening of a new laboratory to explore the diagnosis, clinical treatment, and causal relationships of the disease. Dr. Brian Anderson, the laboratory's director and professor of medicine, indicated that the scientific community now regards the possible link between Reye's Syndrome and budworm spray operations as a blind alley. He suggests that the most promising method of combating the disease is to control measles and influenza in children.

Five New Studies in the West

CANUSA-West management thanks those Forest Service investigators who returned surplus funds near the end of U.S. Fiscal Year 1981. These monies were used to fund the following investigations:

Study Title	Principal Investigators
Silviculture and history of spruce budworm in the northern Rocky Mountains	G. Blake and S. Running, University of Montana Missoula, Montana
Determining the ratio of actual to expected eggs of western budworm at selected sites in the West	R. Campbell and T. Torgersen, Forestry Sciences Lab, Corvallis, Oregon C. Hatch University of Idaho, Moscow, Idaho
Genetic characteristics of western spruce budworm populations	M.W. Stock University of Idaho, Moscow, Idaho
Foliar analysis of selected sites in New Mexico—an extension of "A Determination of the effects of nitrogen and terpenes on western spruce budworm dynamics"	R. Cates University of New Mexico, Albuquerque, New Mexico
Photographic reference guide for spruce budworm defoliation	J. Ulliman University of Idaho, Moscow, Idaho

Personnel

CANUSA-West welcomed several new faces during the fall. Ramona Monge (pronounced MonHAY) is the Program's new clerk typist/word processor operator. She replaces Marlee Smith, who transferred to the Pacific Northwest Stations' Forest Residues Program late last June. Marlee now works with the Helistat development portion of that program.

Kathleen Sheehan-Akers reported October 1 to work for the Program as an insect modeller, through a cooperative agreement with the University of Idaho. Kathy is filling the position vacated when Peter McNamee left CANUSA early in 1981. Since Pete left, Bill Kemp, a Ph.D. candidate working with Dale Everson and Don Burnell on their climatology grant, has been working part-time on insect modelling. Bill comes to the western team with an extensive background, having worked for CANUSA-East as coinvestigator on the Green Woods Project after completing a master's degree with Gary Simmons at the University of Maine, Orono.

Martha Brookes, editor with the Pacific Northwest Forest and Range Experiment Station in Corvallis, Oregon, will take lead editorial responsibility for CANUSA-West. Martha's experience with the Douglas-fir Tussock Moth R&D Program will be extremely valuable; she will edit the publications of the western component, including the three "major books" on management of budworm-susceptible forests.

Martha Brookes, Pacific Northwest Forest and Range Experiment Station editor, is working with the U.S.-West Program to compile and edit three management-oriented books. (Photo by Thomas Brookes)

Items from the Press

Contracts for research on antibudworm agents — Memorial University in St. John's has been awarded two contracts to conduct research on biological controls of the spruce budworm.

The contracts were awarded under the Canada-Newfoundland Forestry Subsidiary Agreement and were announced jointly Thursday November 12, 1981, by national revenue minister William Rompkey and provincial forestry minister Charlie Power.

The first contract, valued at about $7,000, is for the investigation into the use of nematode or roundworm as a control agent. The work will be carried out by Dr. Jean Finney and Dr. Gordon Bennett

The second contract is for $15,000 and will involve research on the production of resting spores or fungus which can kill the budworm. The project will be carried out by Dr. Richard Nolan.

The reports for both studies will be completed early in 1982.

Both Mr. Rompkey and Mr. Power expressed the hope that research of this nature will lead to the development of new and improved biological controls for the budworm so that reliance on chemical controls may eventually be reduced.

They said that all new development of spruce budworm research is being monitored and they are optimistic that the results of these studies will be beneficial.

The contracts are funded 90 per cent by Ottawa, with the province assuming the remaining 10 per cent of the costs.

(The Daily News—Nov. 13, 1981)
St. John's, Newfoundland

Budworm population in most N.S. areas expected to decline—The spruce budworm, No. 1 enemy of Nova Scotia's forest industry, may be eating itself out of house and home in parts of the province, Lands and Forests Minister George Henley says.

Canadian Forestry Service figures show the budworm population, target of a $2.25-million spray program over the last three years, has declined in most areas and is expected to decrease again next year.

But Mr. Henley said recently the budworm population in Cape Breton, hardest-hit area of the province, may be declining because there is nothing left for the insect to destroy.

(Globe and Mail—October 29, 1981)
Toronto, Ontario

Forest industry: Food for worms —The notoriety pro—vincial governments in Atlantic Canada gained from the spraying of spruce budworm is nothing to the ravages the disease has caused to one of the region's most valuable resources.

Moreover, the budworm blight, together with inadequate forest management, threatens to cause severe shortages of timber within 10 years. However, provincial governments are scrambling into action with beefed up spraying efforts and new or at least more stringently enforced forest management legislation, but they admit time is not on their side.

And even if it was, there is no doubt expansion of the forest industry will be prevented for at least several decades until improved silviculture has a chance to replace the predominantly mature forest stands.

(Financial Post—Sept. 12, 1981)
Toronto, Ontario

Lower toll from budworm in Ontario—A forest survey this summer has shown a decline in the area of Ontario forests infested by the spruce budworm, but a sharp increase in damage by the gypsy moth.

Aerial and ground surveys for insects and disease, conducted by the Great Lakes Forest Research Centre, showed that budworm infestations declined in all three main geographical areas of the province where the insects were found. The only exception was in an area around Terrace Bay, on Lake Superior.

The over-all decline, to about 45.5 million acres this year from 47 million in 1980, has been anticipated because of a reduced number of eggs found in the 1980 survey.

(Globe and Mail — September 11, 1981)
Toronto, Ontario

The war against insect "harvesters"—Insects and diseases are chewing a 16-million-cubic-metres-a-year hole in British Columbia's forests.

Federal scientists and technicians of the Canadian Forestry Service are working in partnership with provincial foresters and the forest industry to monitor and check the infestations which—in some parts of the province—have become runaway epidemics.

In this war against the beetles, caterpillars, budworms, weevils, fungi and parasitic plants that destroy nearly five times more timber than the annual loss by fire, the main federal effort is to supply the scientific ammunition for the provincial and industrial foresters who are on the front line of forest management.

(Journal of Logging & Sawmilling—August 81)

Budworm ravaging Ontario balsam firs—About 60 per cent of balsam fir trees in northeastern Ontario—totalling about 1.024 billion cubic feet of timber—have died since the spruce budworm appeared in 1967, a survey by the Canadian Forestry Service says. The annual survey said more wood has been lost each year because of the spruce budworm than from any other factor—about 10.594 billion cubic feet. The survey said the area damaged increased by 2.75 million acres to 90.5 million acres in 1980. Damage also occurred in scattered areas of Manitoba and the Northwest Territories.

(Globe and Mail—July 28, 1981)
Toronto, Ontario

Recent Publications

From the University of Maine's Life Sciences and Agricultural Experiment Station, Orono, ME 04473, interested readers may order this report:

Robert K. Lawrence and Mark W. Houseweart. 1981. "Impact of the spruce budworm in the Maine spruce-fir region, 1975-1979."
Cooperative Forest Research Unit, Res. Bull, 3.
School of Forest Resources, Univ. of Maine.

And in the June 23, 1981, issue of *Pacific Insects*, we call your attention to John D. Stein's article "Notes on the biology of the western spruce budworm, *Choristoneura occidentalis* (Lepidoptera: Tortricidae), in north central Washington."

Other reports of interest recently available from various locations are as follows:

From Peter Kingsbury at the Forest Pest Management Institute, CFS, P.O. Box 490, Sault Ste. Marie, Ont. P6A 5M7:

S.B. Holmes and R.L. Millikin. 1981. "A preliminary report on the effects of a split application of Reldan® on aquatic and terrestrial ecosystems." File Report No. 13.

J. Armstrong. 1981. "ULY/CDA optimum spray droplet size for control of eastern spruce budworm in Canada." Outlook on Agriculture 10(7) 327-332.

From Bud Irving, Forest Protection Limited, Box 1030, Fredericton, N.B. E3B 5H1:

Dr. Charles J. Wiesner. 1981. "Problem analysis and feasibility study for a New Brunswick Spray Efficacy Programme." Technical Report 80/T/4 (NBRPC, RPC Report No. c/81/33, Job No. 6252).

From Bill Ernst, Environment Canada, EPS, Atlantic Region, 5th Flr., Queens Square, 45 Alderney Drive, Dartmouth, N.S. B2Y 2N6:

B. Ernst, G. Julien, K. Doc, and R. Parker. 1981. "Environmental investigation of the 1980 Spruce Budworm Spray Program in New Brunswick." Surveillance Report EPS-5-AR-81-3, Atlantic Region, November 1980.

From the Pest Control Section, Ontario Ministry of Natural Resources, Maple Ont. L0J 1E0:

J.R. Carrow, S. Nicholson, and R. Campbell. 1981. "Aerial spraying for forest pest management: An operational manual."

And from CANUSA-West, 809 N.E. 6th Ave. Portland, OR 97232:

J. Colbert, J.N. Crookston, W. Kemp, and N. Srivastava. 1981. "Description of the combined PROGNOSIS/Western Spruce Budworm Model, Version 3.0."